PreCam: the Precursor to the Dark Energy Camera (DECam)

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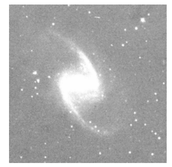


The Era of Observational Cosmology

Observations show that the cosmos is dominated by a mysterious "**Dark Energy**" that drives the accelerated expansion of the universe. The properties of Dark Energy can be expressed in terms of its Equation of State as a function of redshift:

$w(z) = p/\rho$

We parameterize w(z) as follows:

$w(z) = w_0 + w_a(1-a)$, where **$a=(1+z)^{-1}$**

The Dark Energy Survey (**DES**), to be undertaken on the Blanco Telescope at Cerro Tololo InterAmerican Observatory (CTIO), will repeatedly observe **5000 deg^2 of the southern sky**, significantly improving measurements of w_a and w_0 (see Fig. 1).

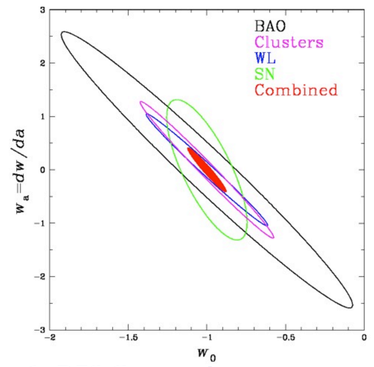


Fig. 1: DES Constraints on w_0, w_a

PreCam: The Instrument

A precursor survey to the DES was undertaken with a specially-constructed instrument known as **PreCam**. PreCam consists of **two 2k x 4k CCDs** identical to those used in the DECam, along with a **pressure control system**, **cryogenics**, and other hardware functionally similar to the DECam. PreCam also incorporates scaled-down **DECam filters**, **readout electronics**, and **software infrastructure** for instrument control and telemetry feedback. PreCam, shown in Figure 2 mounted on the University of Michigan Curtis-Schmidt telescope at CTIO, was awarded **100 nights** of observing time (including instrument commissioning) from Aug. 2010 to Jan. 2011.

Fig. 2: PreCam on the Curtis-Schmidt

Calibration of the Dark Energy Survey with PreCam Observations

PreCam observations (detailed in Table 1) are expected to **save the DES** up to **10% of its survey time** by providing calibration data for **hundreds of stars per square degree** in a sparse grid across the DES footprint (shown as blue lines overlaying the grey region in Figure 3). Calibration data include **extinction standards** and **nightly photometric solutions** which will contribute to improving the DES global relative calibrations from the **2% requirement** to the **1% goal**. It will also contribute to **Sloan Digital Sky Survey (SDSS) to DES Transformations** based on repeated observations of Stripe 82, and it will provide important new data on **Southern Hemisphere Y-band standard stars**. Finally, PreCam will provide a **bright star catalog** for subsequent DES Image Quality tests as well as **science data for bright objects** in the DES footprint such as Milky Way red giants or local supernovae.

Band	PreCam Exposure Time [seconds]	PreCam saturation limit	DES saturation limit (100s exposure)	PreCam mag limit (S/N=50)	PreCam detection limit (S/N=5)	# Stars per sq deg, DES sat to PreCam S/N=50
(1)	(2)	(3)	(4)	(5)	(6)	(7)
g	36	12.8	16.3	17.8	20.9	186
r	51	13.2	16.3	17.8	20.7	265
i	65	13.4	16.2	17.7	20.5	344
z	162	14.1	16.0	17.5	20.1	317
y	73	11.6	14.3	15.8	18.5	150

Table 1: PreCam Expected Observations

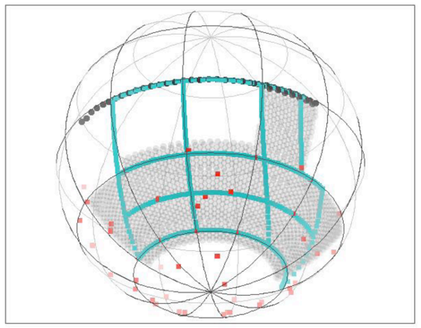


Fig. 3: PreCam Grid, DES Footprint, and Southern Standard Star Fields

PreCam: Observations

PreCam has completed **multiple tilings** (overlapping observations) in the g,r, and i filters of all but the westernmost portions of the DES footprint (areas which were not visible during the PreCam observing period). Significant portions of **SDSS Stripe 82** likewise have been observed multiple times in all five filters. Filter-specific coverage maps and representative images of a region of Stripe 82 are shown in Fig. 4.

In addition, the science observations performed with PreCam have afforded the DES Collaboration with many **opportunities to test the hardware, software, and observing strategies** to be used in the larger Survey. The on-sky experience of PreCam led to a number of potential risks to the DES being identified, resulting in important improvements to various DECam components in order to alleviate these risks. A **second season of PreCam** to complete the remaining tilings is currently being planned, pending the awarding of additional funding and telescope time.

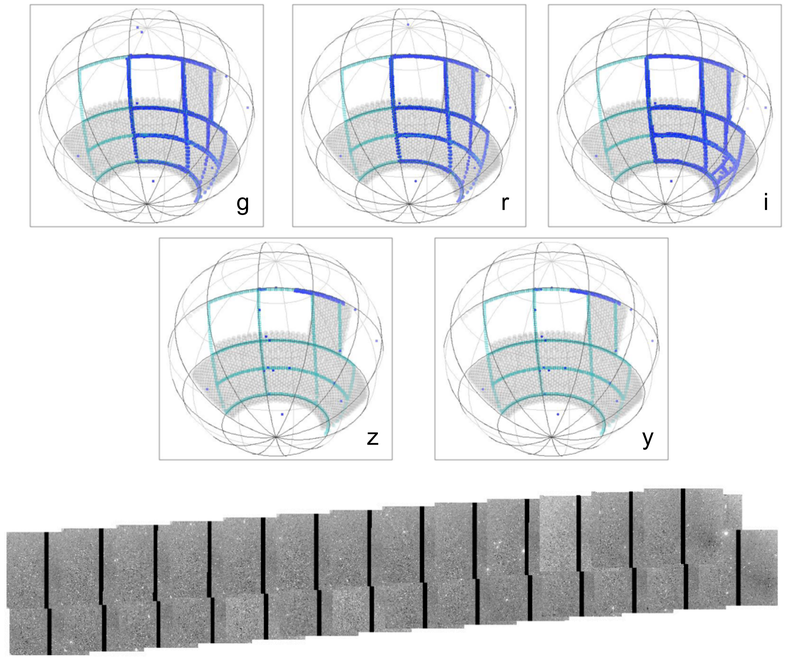
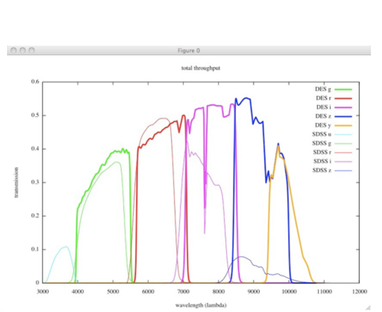


Fig. 4: Filter Coverage maps and a mosaic from Stripe 82

PreCam Preliminary Results: SDSS-DES Color Transformations

A **filter response curve** has been measured for the DES filters employed in PreCam. From these, the expected color terms relative to SDSS can be determined and compared with observations. **Laboratory measurements** of the DES filter response curves compared to SDSS filters (including CCD quantum efficiency), as well as results showing the **close match between expected and observed color terms** for the i and z filters, are shown in Fig. 5.



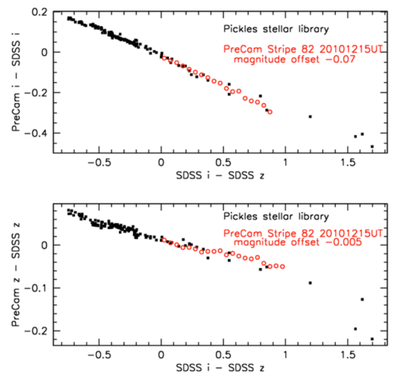


Fig. 5: Filter Response Curves and SDSS-DES Color Terms

PreCam Preliminary Results: Photometric Standards

PreCam stellar fields were observed in order to determine magnitudes for known standard stars, thereby determining the **photometric accuracy** of PreCam (see Fig. 6). Preliminary results show a filter-dependent photometric accuracy **between 2% and 5%**. Several additional image processing steps have yet to be applied to the data; once these are completed, we expect the **final catalog of standard stars** to possess at least the **required 2% photometric accuracy**.

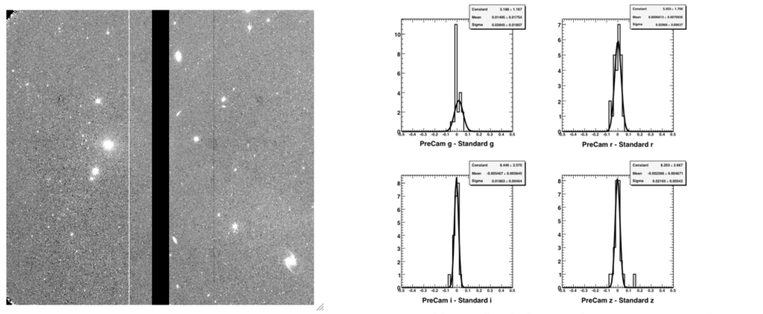


Fig. 6: A representative PreCam stellar field and statistical measurements of PreCam photometric accuracy

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